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Method for Producing a Microtransponder

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method for producing a microtransponder, especially a microtransponder of the type having a circuit chip which contains the transponder electronics, and having in addition a coil metallization which acts as an antenna.

Description of Prior Art

Due to the development of contact-bearing and contactless chip cards, a completely new and rapidly growing market for electronic microsystems has come into existence. Integrated circuits are nowadays installed not only in large devices or manually held systems, but they are installed so to speak "naked" in chip cards. A consistent further development leads to the so-called "throw-away electronics", the first representative of which was the telephone card. More recent fields of use for this so-called "throw-away electronics" are electronic labels which necessitate economy-priced chips or micromodules in economy-priced, ecologically acceptable supports. The simplest case of an electronic label would be a contactless module embedded between two pieces of paper, the contact module comprising an integrated circuit and an antenna coil.

Transponder modules for electronic labels are disclosed in the Patent Abstracts of Japan, publication number 09297535A, relating to the Japanese application 08109052 and the Patent Abstracts of Japan, publication number 09293130A relating to the Japanese application 08109051. In the case of the electronic labels described in the above-mentioned publications an integrated circuit chip together with an antenna are cast in a film-like resin. This film-like resin is then introduced into a metal mould where an outer resin is cast around the film-like resin.

The Patent Abstracts of Japan, publication number 090198481A, relating to Japanese application 08005845 disclose an electronic label in the case of which a circuit chip and a loop-type antenna are applied to a substrate, the outer end of the antenna being connected to a terminal on the integrated circuit via a bridging metallization which is conducted over the windings of the antenna and which is separated from these windings by means of an insulating resin layer.

The Patents Abstracts of Japan, publication No. 08216573A, relating to Japanese application 07021785 describes a contactless IC card comprising a circuit chip and an antenna section. The circuit chip is attached to a circuit section provided on a polyester film, the antenna section being formed on this polyester film as well. By means of an adhesive layer, a second polyester film, which embeds the circuit chip, is formed on the first polyester film. In addition, a third polyester film is applied to the surface of the second polyester film by means of a further adhesive layer.

In DE 19639902 A1 contactless chip cards and methods of producing the same are described. The chip cards described in

this publication comprise an electrically insulating, one-piece card body having one or a plurality of openings on one side thereof. Furthermore, a conductor pattern is provided on the surface of the card body, the conductors being directly applied to surface areas of the card body side provided with at least one opening, and the openings having arranged therein one or a plurality of chips which are bonded to at least one of the conductors.

A survey of known methods of applying integrated circuit chips to a substrate, e.g. by means of a flip-chip method, is contained in H. Reichl, et al: Packaging-Trends: "High-Tech im Kleinstformat", Elektronik 12/1998 (or SMT Nürnberg 98, Conference Proceedings).

SUMMARY OF THE INVENTION

It is the object of the present invention to provide an economy-priced method, which permits the production of ultraflat microtransponders that are suitable to be used e.g. for electronic labels.

This object is achieved by a method for producing a microtransponder in the case of which an antenna metallization having a first and a second connecting end is first applied to a support substrate. Furthermore, a connecting metallization is applied to a flexible support foil, whereupon a circuit chip having a first and a second connecting area is applied to the connecting metallization in such a way that at least the first connecting area of the circuit chip is connected to the connecting metallization in an electrically conductive manner. The support substrate and the support foil

are then joined in such a way that the connecting metallization is connected to the first connecting end of the antenna metallization in an electrically conductive manner and the second connecting area of the circuit chip is connected to the second connecting end of the antenna metallization in an electrically conductive manner. Edge areas of the flexible support foil are then joined to neighbouring areas of the support substrate so as to encapsulate at least the circuit chip.

It follows that the present invention provides a method for producing a microtransponder in the case of which two modules are initially formed, which are joined in the last step. The first module comprises a support substrate, which may consist e.g. of plastic material or of paper and on which the antenna metallization, i.e. the coil, is formed. The second module comprises a thin support substrate, which consists preferably of plastic material, and which has applied thereto one or more connecting metallizations and the circuit chip. These two modules are then joined in such a way that the contacts required for the electric connections between the coil and the circuit chip are realized. The support foil is then used for encapsulating the circuit chip and optional further areas of the coil metallization and of the connecting metallizations, respectively, by joining edge areas of the support foil with neighbouring areas of the support substrate by means of welding or by means of an adhesive so that especially the circuit chip can be protected against external influences.

According to the present invention, the two modules can first be processed separately from one another so that one module can be processed without taking into consideration the re-

spective other module. The two modules can then be joined in such a way that, when they are being joined, all the necessary electric connections will be established. Through-contacts through the support substrate, which are only required in the case of some embodiments, have to be established in a separate step before or after the joining of the two modules. When the two modules have been joined, the thin support foil, which, on the one hand, serves to handle the circuit chip and the connecting metallization, is used in accordance with the present invention for encapsulating at least the circuit chip and preferably also the areas in which the connections between the connecting metallization and the antenna metallization are realized, by joining edge areas of this thin support foil to the support substrate by means of welding or by means of an adhesive. This encapsulation is carried out preferably in a vacuum or making use of a protective gas so as to prevent an inclusion of possibly detrimental substances.

Embodiments and further developments of the present invention are defined in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, preferred embodiments of the present invention will be explained in detail making reference to the drawings enclosed, in which respective identical elements are designated by identical reference numerals.

Fig. 1a) to 1e) show a schematic representation for illustrating a first embodiment of the method according to the present invention;

Fig. 2a) to 2d) show a schematic representation for illustrating a second embodiment of the method according to the present invention;

Fig. 3a) to 3e) show a schematic representation for illustrating a third embodiment of the method according to the present invention;

Fig. 4a) to 4e) show a schematic representation for illustrating a fourth embodiment of the method according to the present invention;

Fig. 5a) to 5e) show a schematic representation for illustrating a fifth embodiment of the method according to the present invention;

Fig. 6a) to 6c) show a schematic representation for illustrating a sixth embodiment of the method according to the present invention;

Fig. 7a) to 7c) show a schematic representation for illustrating a seventh embodiment of the method according to the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Making reference to Fig. 1, the first embodiment of the method according to the present invention will now be explained in detail. As has been stated above, two separate modules are first produced in the case of the method for producing a microtransponder according to the present invention.

The first module produced is shown in Fig. 1a). In the case of this embodiment, a first connecting metallization 2 and a second connecting metallization 4 are first applied to a thin support foil 6, which consists preferably of plastic material, so as to produce this first module, which can also be referred to as circuit chip module. Subsequently, a circuit chip 8 is applied to the connecting metallizations 2 and 4. The circuit chip 8 comprises the integrated circuit required for the microtransponder and is provided with two connecting areas on or in one main surface thereof; for operating the microtransponder, these connecting areas must be connected to respective connecting ends of a coil antenna metallization. The circuit chip 8 is applied to the connecting metallization 2 in such a way that the first connecting area thereof is connected to the first connecting metallization 2 in an electrically conductive manner, whereas the second connecting area thereof is connected to the connecting metallization 4 in an electrically conductive manner. This results in the structural design of the first module shown in Fig. 1a).

This first module is produced from extremely thin materials. This is important in view of the fact that, when the microtransponder has been finished, the circuit chip 8 with the support foil 6 should not perceptibly project beyond a support substrate on which the coil metallization is arranged. The circuit chip and the foil preferably have a thickness of less than 50 µm.

The connecting metallizations 2 and 4, which may consist e.g. of Al, Cu and the like, can be applied to the foil by arbitrary methods, e.g. by cladding and subsequent structuring, by evaporation or sputtering and subsequent structuring, or alternatively by evaporation or sputtering making use of a

shadow mask so as to apply lines which are already structured. The connecting metallizations may have a thickness of less than 1 µm, since the conductor tracks of the connecting metallizations can be implemented such that they are short and broad. When the connecting metallizations 2 and 4 have been finished, the circuit chip 8 is placed on the contact areas of the connecting metallizations and is connected thereto in an electrically conductive manner; this can be done e.g. by means of thermocompression, anisotropic conductive adhesives or ultrasonic compression.

In Fig. 1b) the second module is shown, which comprises a support substrate 10 and an antenna metallization 12 applied to a main surface of the support substrate 10. The support substrate may consist e.g. of plastic material or paper. The antenna metallization 12, which has the form of a coil, can again be formed on the support substrate 10 by arbitrary known methods. The coil metallization can e.g. be formed by etching a cladding. Alternatively, a wire can be placed onto the support substrate 10 such that a coil is formed. According to another alternative, a metal, e.g. Cu, Al and the like, can be applied to the support substrate 10 by evaporation and structured subsequently. In order to obtain an adequate thickness of the coil metallization 12 the evaporated metallization can subsequently be thickened by means of an electroplating technique. As can additionally be seen in Fig. 1b), a local thin insulating layer 14 is produced, e.g. by means of a printing process, in an area of the coil metallization 12. This local insulating layer is produced in an area onto which the second connecting metallization 4 will be placed later on so as to prevent a short circuit between the second connecting metallization 4 and the coil metallization 12.

At this point reference should be made to the fact that, alternatively to the application of the insulating layer 14 to the coil metallization 12, this local insulating layer may also be formed on corresponding areas of the first module, e.g. by means of a suitable printing process or by surface oxidation of the metallization. Since the lines of the first module are very thin in comparison with the antenna metallization, which may have a thickness of e.g. 4 to 30 μm, it may be more advantageous to form the insulating layer on the first module, which is shown in Fig. 1a). The insulating layer 14 can consist of an acrylic lacquer having a thickness of 0.2 to 2 μm, this acrylic lacquer being then locally removed at the future contact points; this is done by means of a thermal process. If the local insulating layer is formed on the first module, this can be done prior to or subsequent to the application of the circuit chip 8 to the connecting metallizations 2 and 4.

The first module and the second module are now joined in a subsequent step, as shown in Fig. 1c). In so doing, the first connecting metallization 2 is connected to a first connecting end 16 of the antenna metallization 12 in an electrically conductive manner, whereas the second connecting metallization 4 is connected to a second connecting end 18 of the antenna metallization in an electrically conductive manner. In the embodiment shown in Fig. 1, an isoplanar contact is obtained in this way. As can be seen in Fig. 1d), the support foil 6 is then connected along its edges to the support substrate 10 in such a way that, in the embodiment shown, the circuit chip 8 as well as the connecting areas between the antenna metallization and the connecting metallization are encapsulated. This can be achieved by bending the edges of

the thin support foil 6 towards the support substrate 10 and by subsequently joining the foil areas 20 abutting on the support substrate 10 to the support substrate 10 by means of welding or by means of an adhesive, as can be seen in Fig. 1d). It follows that, according to the present invention, an encapsulation of the circuit chip and, in the case of the embodiment shown, of the connection points can be accomplished in a simple manner so as to provide protection against external influences. This connection process between the support foil 6 and the support substrate 10 is preferably carried out in a vacuum.

A top view of the microtransponder produced by means of the above method is shown in Fig. 1e). In this top view, especially the shape of the connecting metallizations 2 and 4 and the arrangement of the insulating layer 14 can be seen.

Fig. 2 shows a schematic representation of a second embodiment of the production method according to the present invention. The method shown in Fig. 2 corresponds essentially to the method described with reference to Fig. 1, the support substrate 10 having, however, provided therein an opening/recess 30 into which the circuit chip 8 is introduced when the first and second modules are being joined. The opening 30 can be formed in the support substrate 10 by means of arbitrary known methods. Since the support foil 6 and the thin connecting metallization 2 provided thereon are flexible, the shape of the support foil 6 shown at 32 in Fig. 2c) is obtained. One advantage of this embodiment of the method according to the present invention is that the opening 30 permits an improved protection of the circuit chip 8 and that, in addition, the circuit chip can be fixed more effectively. The edge areas of the support foil 6 are again joined

to neighbouring areas of the support substrate 10 by means of an adhesive or by means of welding so as to achieve an encapsulation of the circuit chip.

In Fig. 3 a third embodiment of the method according to the present invention is schematically shown. In Fig. 3a) the second module is shown, which corresponds to the above-described second module. In Fig. 3b) the first module is shown, which also corresponds to the above-described first module. Other than in the case of the above-described embodiments, the first and the second module are now, however, joined in such a way that the circuit chip 8 will be positioned on the surface of the support substrate 10 which is located opposite the surface of the support substrate 10 having the antenna metallization 12 formed thereon, cf. Fig. 3c). It follows that in the third embodiment shown, an electrically conductive connection between the first and second connecting ends of the antenna metallization 12 and the first and second connecting metallizations 2 and 4 is not yet established simultaneously with the joining of the first and second modules. In order to realize this electrically conductive connection, through-contacts 40 and 42, respectively, are established, cf. Fig. 3d). By means of the through-contact 42 an electrically conductive connection is established between the first connecting metallization 2 and the first connecting end 16 of the antenna metallization 12, whereas by means of the through-contact 40 an electrically conductive connection is established between the second connecting metallization 4 and the second connecting end 18 of the antenna metallization 12.

In order to establish the through-contacts, thermocompression methods can be used by way of example. Alternatively, the

through-contacts can be produced by means of an ultrasonic compression, by means of welding or by means of soldering. In this respect, it should be pointed out that the through-contacts may already be produced when the two modules have not yet been joined, i.e. in the stage of the second module which is shown in Fig. 3a), so that, when the two modules are being joined, the respective electrically conductive connections between the through-contacts and the connecting metallizations will be produced. As can be seen in Fig. 3e), the edge areas 20 of the support foil are again joined to neighbouring areas of the support substrate 10 by means of welding or by means of an adhesive, so as to encapsulate the circuit chip and, in the embodiment shown, additional areas.

The fourth embodiment of the method according to the present invention shown in Fig. 4 differs from the embodiment which has been described with respect to Fig. 3 insofar as the surface of the support substrate 10 located opposite the antenna metallization 12 has formed therein an opening 50 into which the circuit chip 8 is introduced when the first and second modules are being joined. As can be seen in Fig. 4c, this permits an isoplanarity of the connecting metallizations 2 and 4. As in the case of the embodiment according to Fig. 3, through-contacts 40, 42 are again produced for establishing an electrically conductive connection between the connecting metallizations 2 and 4 and the first and second connecting ends 16 and 18 of the antenna metallization 12. Furthermore, also according to the fourth embodiment, the edge areas 20 of the support foil 6 are joined to neighbouring areas of the support substrate 10 by means of welding or by means of an adhesive so as to effect an encapsulation.

In the case of the method shown in Fig. 5, a circuit chip 60 is used, which is provided with a first connecting area on a first main surface thereof and with a second connecting area on a second main surface thereof. The first module shown in Fig. 5a) is now formed by applying a single connecting metallization 62 to a support foil 6. The circuit chip 60 is applied to the connecting metallization 62, an electrically conductive connection being established between the connecting area of the circuit chip 60 and the connecting metallization 62 e.g. by means of conductive adhesives or by means of soldering.

Fig. 5b) shows the second module; for producing this second module, an antenna metallization 64 is first applied to a support substrate 10. As can be seen in Fig. 5b), the antenna metallization 64 has a preferably enlarged second connecting end 66, the circuit chip 60, whose lower surface may be provided with a metallization 68 thickening the connecting area, being applied to this second connecting end 66 when the first and second modules are being joined. As has already been explained with reference to Fig. 1, a local insulating layer 70 is formed on respective areas of the antenna metallization 64 also in the case of the embodiment shown in Fig. 5 so as to prevent later on a short circuit between the connecting metallization 62 and the antenna metallization 64.

The first module is now connected to the second module, cf. Fig. 5c), a contact between the metallization 68, i.e. the second connecting area on the lower surface of the circuit chip 60, and the second connecting end of the antenna metallization 66 being established simultaneously, and an electrically conductive connection between the connecting metallization 62 and the first connecting end 72 of the antenna metal-

lization 64 being established simultaneously. As can be seen in the detail representations shown in Fig. 5d), the edge areas 20 of the support foil 6 are connected, i.e. joined by means of welding or by means of an adhesive, to corresponding neighbouring areas of the support substrate 10 also in the case of this embodiment. Fig. 5e) shows a top view of the resultant microtransponder.

In the sixth embodiment of the method according to the present invention, which is schematically shown in Fig. 6, a first module is again prepared, which essentially corresponds to the first module shown in Fig. 5. This first module is shown in Fig. 6b). The second module differs from the module described with reference to Fig. 5 insofar as an opening 80 is formed in the main surface of the support substrate 10 facing away from the antenna metallization 64, Fig. 6a). As can be seen in Fig. 6c), the circuit chip 60 is introduced in this opening 80 when the two modules according to this embodiment are being joined. For establishing an electric contact between the connecting area, or the reinforcement 68, arranged on the upper surface of the circuit chip and the second connecting end 66 of the antenna metallization 64, it is necessary to eliminate, preferably by means of a thermally supported method, the web 82 of the support substrate arranged above the opening 80, so as to establish an electrically conductive connection between the connecting area arranged on the upper surface of the circuit chip 60 and the second connecting end 66 of the antenna metallization 64. Furthermore, a through-contact 84 is produced so as to establish an electrically conductive connection between the connecting metallization 62 and the first connecting end 72 of the antenna metallization 64. Also in the case of this embodiment, the edges of the support foil 6 are joined to the

support substrate 10 by means of welding or by means of an adhesive so as to obtain an encapsulation.

Also in the embodiment which is schematically shown in Fig. 7, a circuit chip 60 with double-sided contacting is used. Other than in the case of the method described with reference to Fig. 6, the support substrate 10 has now provided therein an opening 90 which extends through the whole support substrate 10 up to the second connecting end 66 of the coil metallization 64. The rest of the method for producing the microtransponder according to the embodiment shown in Fig. 7 corresponds essentially to the method which has been described with reference to Fig. 6, but the heat treatment for eliminating a web above the opening 90 can now be dispensed with, since such a web does not exist. The other steps correspond to the steps which have been described with reference to Fig. 6.

It should be pointed out that the second connecting end 66 of the antenna metallization 64 may cover the circuit chip 60 completely or partially. Furthermore, the metallization 68 on the circuit chip 60 may cover the circuit chip completely or partially; a person skilled in the art will also be aware of the fact that, with the exception of the connecting area of the circuit chip 60, a passivation layer is arranged between the metallization 68 and the circuit chip 60.

It follows that the present invention provides a simple technique for producing a microtransponder in the case of which the production of the antenna module and the production of the circuit chip module are completely separated. The circuit chip module can be implemented such that it is much thinner than the antenna module. Various production techniques can be

used for producing the antenna module and for producing the circuit chip module. Due to the fact that the circuit chip is encapsulated or that large areas thereof are covered by a metallization, good light protection can be achieved. The methods according to the present invention are preferably executed such that the individual modules are formed on an endless material and are then sequentially supplied to a processing station in which the modules are joined. The respective metallic layers may consist of a ferromagnetic material so as to permit, if necessary, magnetic handling of the individual modules or of the finished microtransponder. For handling the thin circuit chip module, the circuit chip module may be supported by an additional support so as to stabilize it, whereby distortions or even rolling up due to internal mechanical stress can be avoided. The encapsulation of the circuit chip and of additional optional areas is preferably carried out in a vacuum or while a protective gas, e.g. a forming gas, is being supplied.